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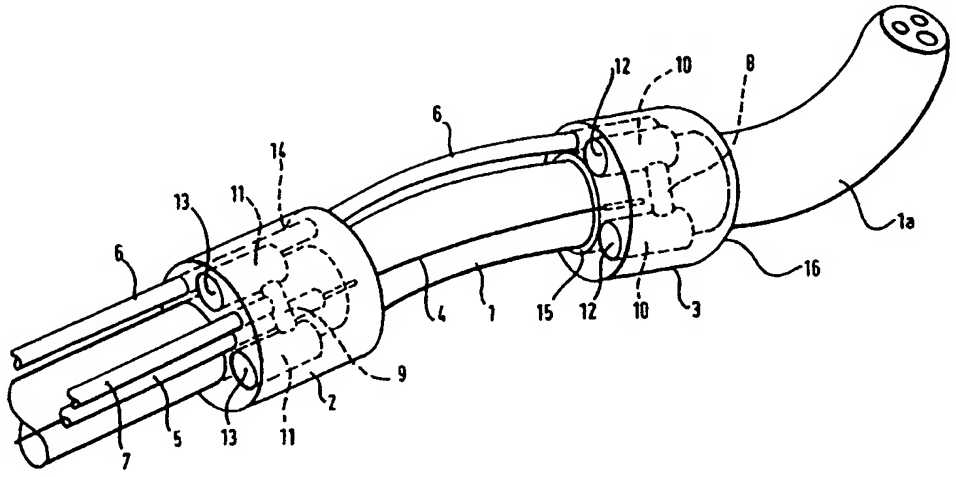
(54) Title: SUCTION MEANS FOR PROPELLING AN ENDOSCOPE



(57) Abstract

An endoscope (1), is provided with a suction head (2, 3) mounted for longitudinal movement with respect thereto. The suction head is arranged, when actuated, to grip the tissue of the body passage such as the colon or small bowel, in which the endoscope (1) is disposed. The endoscope may have a first suction head (2) and a second suction head (3) longitudinally of the endoscope. Movement may be effected by means of a Bowden cable (4, 5).

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SUCTION MEANS FOR PROPELLING AN ENDOSCOPE

This invention relates to a device, for example an endoscope or similar instrument, having means for propelling it along a tortuous passage. Although the invention is not limited to medical applications, the inventors have in mind particularly the problems associated with small bowel endoscopy and colonoscopy. During colonoscopy, for example it is well known that difficulties often arise with pushing the colonoscope through the bends in the colon. When the endoscopist pushes on the colonoscope there is a tendency for the colon, which is in effect a floppy and poorly supported tube, to form an arc or loop, so that further pushing serves only to expand the arc or loop and does not advance the tip of the colonoscope. If the instrument is pushed too hard the wall of the gut may be damaged.

More generally the problem that this invention seeks to overcome is that any instrument designed to be pushed along a tortuous passage must be flexible enough to negotiate the corners yet at the same rigid enough to avoid buckling or forming loops. This invention seeks to avoid this dilemma by providing a means of propulsion at or near the distal tip of the instrument so that it can pull itself through the passage.

The history of colonoscopy has been one of improving instruments for pushing through the anus and along the colon. However, the first successful total colonoscopy was achieved in 1965 by Provenzale and Revignas who simultaneously pushed and pulled a colonoscope through the anus and along the entire length of the large bowel. The pulling involved a long string (actually a small calibre rubber

tube) which had previously been swallowed by the patient who still had one end emerging from his mouth (Provenzale L, Revignas A. Metodica originale di esplorazione strumentale trans-anale polivalente del colon intero. Rass Med Sarda 1966:69:131-140). This technique, involving end-to-end intestinal intubation, did not prove popular and endoscopists reverted to pushing the instrument along the colon.

The obvious desirability of having an instrument that could pull itself along a tortuous tube has led a number of workers to describe methods of providing traction at the distal end of the endoscope. So far as we are aware none of these techniques have been used with humans.

The most common approach has been to imitate the motion of an earthworm by attaching inflatable segments to the endoscope. As described by Frazer (Apparatus for endoscopic examination, US patent 4,176,662) there are two radially expandable bladders separated by an axially expandable bellows with only the forward bladder attached to the endoscope. The sequence of operation is that (1) the rear bladder is expanded to anchor it against the colon wall, (2) the bellows are then expanded to push the front bladder (and hence the endoscope) forwards, (3) the front bladder is inflated so that it is locked in place against the colon wall, then (4) the rear bladder is deflated and finally (5) the bellows are contracted to draw the rear bladder forwards ready to start the next cycle. Variations on the worm theme can be found in patents by Lyddy et al (US patent 4,690,131), Krasner et al (US patent 4,676,228), Utsugi (US patent 4,148,307), Shishido et al (US patent 5,090,259) and Grundfest et al (US patent 5,337,732).

A number of other methods of propulsion have been suggested. For

instance, Goh et al have speculatively proposed using robots; one embodiment looks like a toy car while another looks like a giant ant ("Future developments in high-technology abdominal surgery; ultrasound, stereo imaging, robotics", Baillieres Clinical Gastroenterology, Vol. 7 No 4 Dec. 1993). Krauter (Walking borescope, US patent 4,934,786) and Allred 111 et al (US patent 5,345,925) have proposed ingenious systems to make endoscopes "walk" along the colon.

An aspect of the present invention that will be described later is that it "walks" along the wall of the bowel using suction to anchor its "feet". This use of suction inside the gastrointestinal tract has been described by some of the present inventors in previous patents e.g. EP-A-0174843, where apparatus for suturing inside the gastrointestinal tract was described. This involved sucking a portion of the wall of the gut into a cavity so that a fold of tissue was formed and a needle and thread could be passed through the full thickness of the bowel wall. The purpose of the suction in the previous invention was to hold the tissue in a suitable position for stitching or the like.

The use of suction to provide grip when walking is well known in the animal kingdom and has also found mechanical applications. For example toys have been made that use a rotating wheel with a number of suckers mounted radially to climb up window panes.

A microrobot system for colonoscopy has been described by Carrozza et al in Proceedings of the Seventh International Symposium on Micro Machine and Human Science, pp 223-228, 1996, and in EP-A-0838200. This system uses two suction heads which are movable with respect to one another by a bellows.

According to one aspect of the present invention there is provided an

endoscope having a first suction means mounted thereon and a second suction means mounted thereon for movement with respect to the first suction means longitudinally of the endoscope, the first and second suction means each being arranged, when actuated, to grip the tissue of a body passage in which the endoscope is disposed.

According to another aspect of the invention there is provided an endoscope and a suction means mounted for longitudinal movement with respect thereto, the suction means being arranged, when actuated, to grip the tissue of the body passage in which the endoscope is disposed.

According to a further aspect of the invention there is provided a device having propulsion means for propelling it along a tortuous passage, wherein the propulsion means comprises first and second suction means each arranged, when actuated, to grip the wall of the passage, the first and second suction means being movable with respect to one another in a direction which, in use, is longitudinal of the passage, by a cable, preferably a Bowden cable, interconnecting the two.

Other aspects of the invention will appear from the ensuing description.

Throughout the following description it will be assumed that the device is being used within the bowel, but it could also be used with any similar tissues.

The principle employed in the invention is that suction may be used to attach part of a device to the wall of the bowel and that this attachment can then be used as a fixed point from which to push or pull the rest of the device along the colon. In other words, the sucker provides a foothold that can be used to climb along the bowel. This attachment is not necessarily fixed immovably to the bowel wall and we have observed that when carrying load it may slip slightly without

significantly impairing its function.

It is possible that a single sucker could be used; for example a cup could be pushed forward from the tip of an endoscope and then attached to the wall and used as an anchor from which to pull the endoscope forward. However, it is preferable that two or more suckers are used, so that the device can walk using the suckers as feet.

The suction cup must be lightly pressed against the tissue before the suction can grip hold of the tissue. This can reliably be achieved by sucking air out of the bowel until it collapses onto the suction cup. The moment at which the tissue becomes trapped can be monitored by the change in pressure or air flow at the vacuum pump. Once the tissue has been trapped in the suction cup, the lumen of the bowel can be reflated to facilitate advancing the endoscope and inspecting the bowel.

In the accompanying drawings:

Figure 1 is a perspective view of an embodiment of the present invention; and

Figures 2a and 2b illustrate a situation which shows the desirability of using a Bowden cable.

Figure 1 shows a flexible endoscope 1 having a flexible tip 1a. The endoscope is provided with two annular suction heads 2, 3 with the distal head 3 able to slide along the endoscope, while the proximal head 2 is fixed to the shaft of the endoscope with an easily removable adhesive, or a collet or other clamping device. The two heads are moved relative to each other by means of a Bowden cable whose inner wire 4 is stiff enough to push the distal head forward without

buckling, but not so stiff as to significantly affect the rigidity of the endoscope. In the illustrated embodiment the Bowden cable runs outside the endoscope, but an alternative would be for the endoscope to be provided with an extra channel specifically to carry the cable. The outer sheath of the Bowden cable is denoted by reference numeral 5. Both heads are connected to the outside by separate tubes 6, 7 that can be used for suction or air blowing or water flushing. The suction is used to attach to the bowel wall, the blowing is used to inflate the bowel to facilitate advancing the endoscope, while the water flush is used after each application of suction to clear debris from the suction chambers and tubes.

The outer sleeve of the Bowden cable does not move relative to the endoscope and the proximal end of the cable is mounted onto a yoke that is attached to the handpiece of the endoscope. The Bowden cable may be hand operated, or it could be motorised with, for example, a bi-directional finger switch being added to the yoke. As illustrated, the Bowden cable and the two suction tubes are all separate. It would be possible to produce a more convenient version of the instrument by arranging the tubes coaxially and using them as a type of Bowden cable with the inner tube not only carrying suction to the distal head but also pulling and pushing it back and forth.

Each suction tube 6, 7 communicates via a respective cross channel 8, 9 with a pair of suction chambers 10, 11 which are open to the exterior of the heads at opening 12, 13. In use, the tissue of the colon is sucked partially into these openings. As shown, the openings are at the proximal ends of the chambers. They could, however, be disposed elsewhere, i.e. at the distal ends of the chambers or at the radially outer regions of the chambers.

To enable the distal suction head 3 to move with respect to the endoscope, the suction tube 6 to the distal head passes with a clearance through a channel 14 in the proximal head 2. Also, a PTFE bush 15 is secured to the inner radial surface of the head 3 to enable it to slide easily along the endoscope surface. Finally, it is to be noted that the distal end 16 of the head 3 is tapered in a shape resembling a bullet, to enable it to slide easily along through the colon.

Once inserted into the colon, the sequence of operation, either manual or automated is as follows:

Step	Bowden cable	Proximal head	Distal head
1	Contracted	Suck to catch tissue	Closed
2	"	Suck with tissue caught	Blow
3	Expand	"	"
4	Expanded	Closed	Suck to catch tissue
5	"	Blow	Suck
6	Contract, pulling scope forward	"	"
7	Contracted	Suck to catch tissue	Closed

In practice, the suction catches the tissue very easily and it is usually possible to catch the tissue with one head while the other head is still blowing and the colon is not fully deflated. This makes it possible to merge step 1 with step 2, and step 4 with step 5.

An advantage of using a Bowden cable is that it allows the two heads to be pulled very close together, thereby minimising the amount of tissue that can be

"concertinaed" between the two heads. This is important, for if the tissue becomes bunched up between the suction heads it can itself behave like a bellows and move back and forth as the gap between the heads is expanded and contracted, with the result that it cancels out the motion of the suction heads so that there is less tendency to advance the endoscope. Figures 2a and 2b illustrate an extreme case of this where no progress is made because too much tissue is concertinaed between the heads in the contracted state. Figure 2a shows the heads in the expanded state and Figure 2b shows the heads in the contracted state. Reference numeral 20 denotes the bowel wall.

Suction along the lines described above can also be used not to propel an endoscope along the colon or small bowel but to anchor an object therein. For example, the object, with its suction means, can be introduced via the anus by pushing it using, for example, a conventional endoscope, and then caused to anchor itself in place on the wall of the colon or small bowel using suction.

CLAIMS:

1. An endoscope and a suction means mounted for longitudinal movement with respect thereto, the suction means being arranged, when actuated, to grip the tissue of the body passage in which the endoscope is disposed.

2. An endoscope having a first suction means mounted thereon and a second suction means mounted thereon for movement with respect to the first suction means longitudinally of the endoscope, the first and second suction means each being arranged, when actuated, to grip the tissue of a body passage in which the endoscope is disposed.

3. An endoscope according to claim 2, wherein one of the first and second suction means is fixedly mounted with respect to the endoscope, and the other of the first and second suction means is mounted for longitudinal movement with respect to the endoscope.

4. An endoscope according to claim 3, wherein the fixedly mounted suction means is located proximally with respect to the movably mounted suction means.

5. An endoscope according to any one of claims 2 to 4, wherein a cable is arranged to effect longitudinal movement of the suction means with respect to one another.

6. An endoscope according to claim 5, wherein the cable is a Bowden cable.

7. An endoscope according to any preceding claim, connected to means for applying suction to the suction means.

8. An endoscope according to claim 7, provided with means for selectively supplying air or flushing liquid to the suction means.

9. A device having propulsion means for propelling it along a tortuous passage, wherein the propulsion means comprises first and second suction means each arranged, when actuated, to grip the wall of the passage, the first and second means being movable with respect to one another in a direction which, in use, is longitudinal of the passage, by a cable, preferably a Bowden cable, interconnecting the two.

10. A device according to claim 9, in the form of an endoscope.

11. A method of examining the interior of the colon or small bowel, which comprises introducing thereinto an endoscope according to any one of claims 1 to 8 and 10, and causing it to move therealong.

12. A device intended to be held in the colon or small bowel, which comprises suction means for anchoring it on the wall thereof.

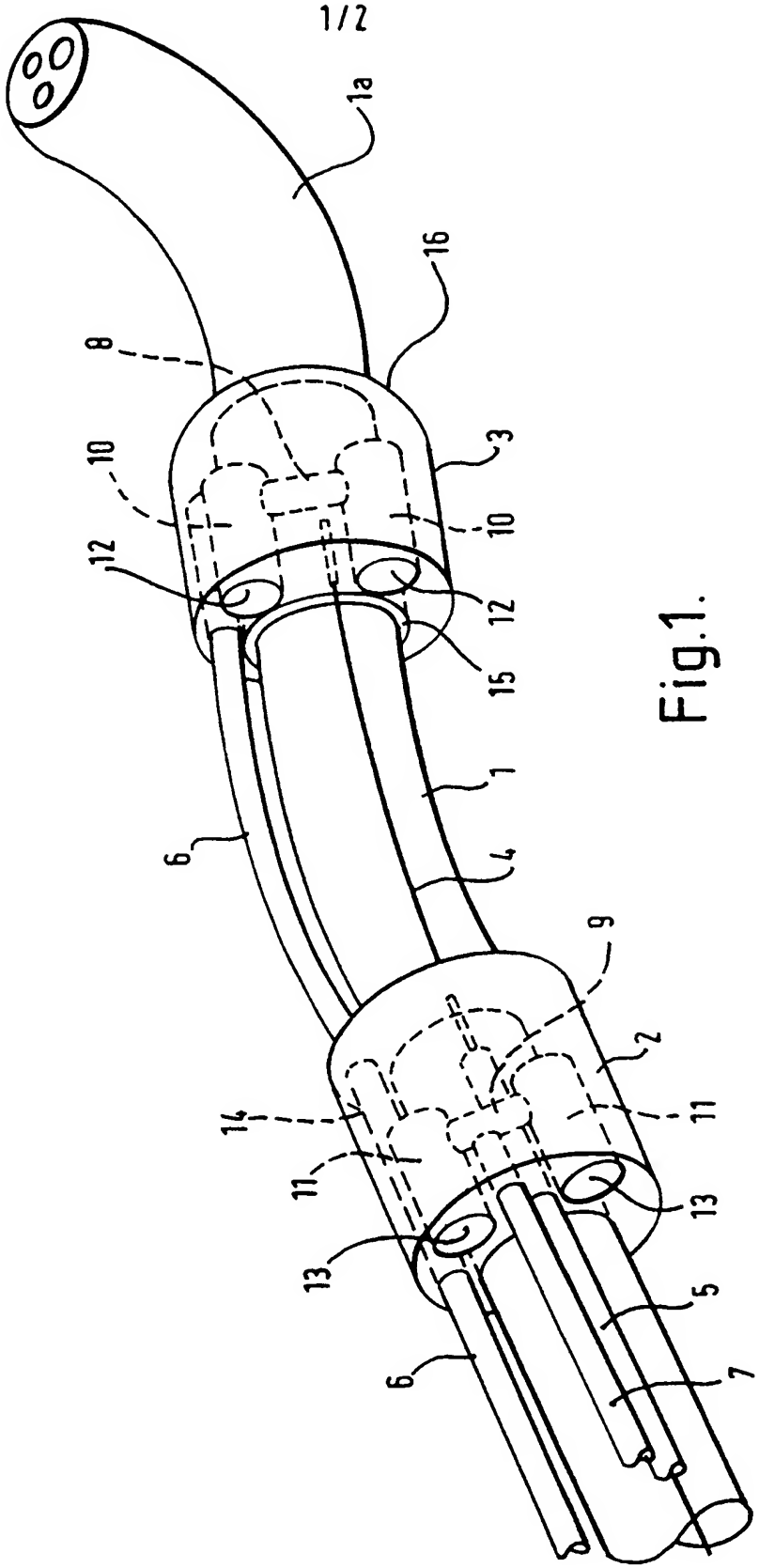

Fig.1.

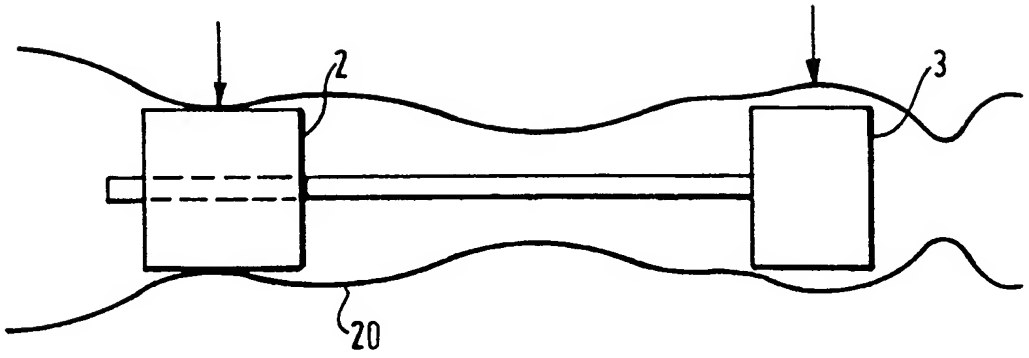

Fig.2a.

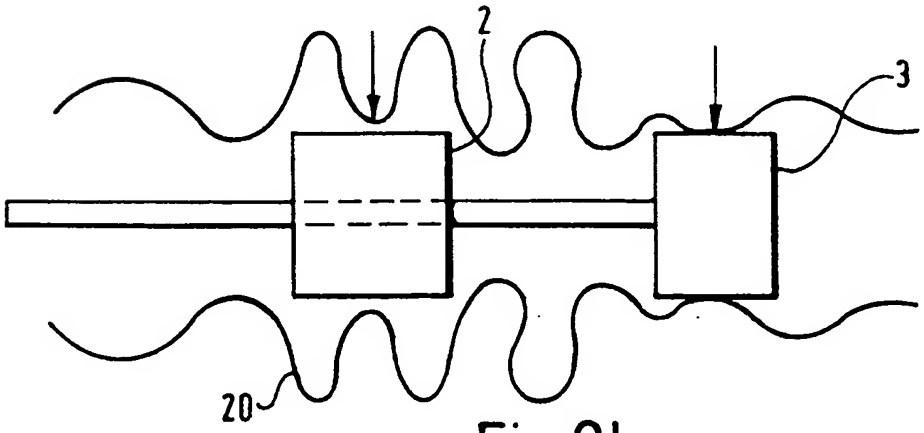

Fig.2b.

INTERNATIONAL SEARCH REPORT

Inter. onal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61B1/005 A61B1/31

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 1 278 965 A (MAISON DRAPIER, VAN STEENBRUUGE & BRETON) 13 April 1962 (1962-04-13) page 1, column 1, line 1 - line 36 page 1, column 2, line 33 - page 2, column 2, line 7	1-4,7-12
X	WO 96 00517 A (COLUMBIA UNIVERSITY) 11 January 1996 (1996-01-11)	1,7,8
X	page 14, line 24 - page 17, line 27	10-12
A	page 21, line 15 - line 17	2,9
A	DE 36 30 660 A (L. REINHARDT) 17 March 1988 (1988-03-17)	5,6
A	column 1, line 54 - column 2, line 24; claims 1,2,4	10,11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 1278965 A	13-04-1962	NONE	
WO 9600517 A	11-01-1996	US 5595565 A	21-01-1997
		AU 2953595 A	25-01-1996
DE 3630660 A	17-03-1988	NONE	